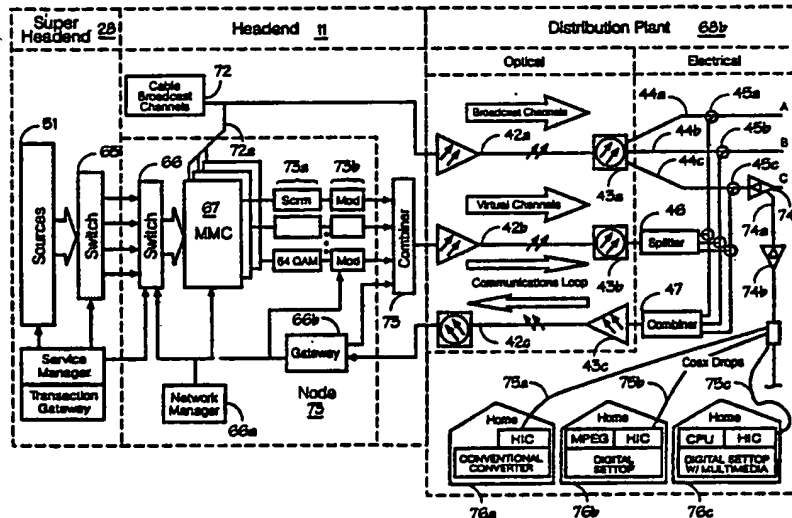




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(54) Title: INTERACTIVE HOME INFORMATION SYSTEM



(57) Abstract

A system in some embodiments achieves distribution of conventional cable services in traditional manners while providing interactive television information services on a demand basis using a switching arrangement, and it does so while permitting both types of service to be accessed, as in the past, by the single action of channel selection. In a preferred embodiment, an interactive television information system, providing interactive cable television service when coupled to a cable television system, has (i) an information source available at a headend (11) for supplying a plurality of information services and (ii) an information service distribution (68b) network for delivering the information services to subscriber televisions. Various architectures are provided.

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INTERACTIVE HOME INFORMATION SYSTEM

Technical Field

The present invention relates to cable television systems, particularly those having two-way communications capability with the user.

Background Art

Bandwidth problems have long restricted the ability of cable television systems to provide information services to subscribers. Although a coaxial cable system may permit a cable system operator to provide, for example, 50 television channels, each 6 MHz wide, with a total bandwidth of 300 MHz, this total bandwidth is insufficient to permit an arrangement wherein each subscriber may have, in addition to these 50 channels, an interactive information service that functions independently of interactive information services to all other subscribers and provides full color video, motion typical of movies or television, and sound.

The reason for the insufficiency in bandwidth is apparent on a consideration of the demands on the system. Typically a subscriber on a cable system obtains information services over a communication path that starts at the headend, proceeds over one of typically a number of trunks, and then over one of a number of feeders, and then over one of a number of taps. Each feeder may have, for example, fifty or more subscribers, and each trunk might serve a hundred or more feeders. The result is that 5000

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subscribers per trunk is not atypical. Thus merely to provide a private one-way information service, and nothing else, to each of these 5000 subscribers would require the trunk to carry 5000 different signals, each using about 6
5 MHz of bandwidth, and would alone require a trunk bandwidth of 30 GHz, which is nearly two orders of magnitude greater than provided by a typical coaxial cable system.

The use of fiber optic trunks can assist in providing additional bandwidth, but to the extent that coaxial cable
10 secondary trunks and feeders are used in a hybrid fiber-cable system, bandwidth limitations may continue to pose problems. While video compression schemes may assist in bringing the bandwidth requirements within more practical limits, each subscriber would then need to be provided with
15 his own decompression unit.

Another problem lies in how to handle the switching and computing demands on the headend to provide separate and private information service to potentially hundreds of thousands of subscribers simultaneously.

20 In one paper, it has been suggested that a portion of cable system bandwidth be used to provide the most popular channels universally to all subscribers and remaining services be delivered to individual busses on a demand basis only. Large, D., "Tapped Fiber Vs Fiber-Reinforced
25 Coaxial CATV Systems: A comparison of Evolutionary Paths," Draft Paper, 8/4/89, at pages 16 et seq. A three level distributed switching system was proposed, with one switch at the headend to switch among hubs, one at each hub to switch among distribution lines, and a third level
30 "interdiction circuit" to select the service for each dwelling. No architecture for such a scheme was proposed, and the author noted that "a significant development effort will be required". *Id.*, at page 19. Moreover, the author notes that his scheme poses a problem for the subscriber in
35 using the system, because most channels will be accessed in the normal way using the television tuner while switched services must be accessed by first tuning to an available

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switch channel, then using an auxiliary communications device to control that channel. "Given that customers have historically resisted any complications created by cable companies in accessing services, this may be a potential
5 problem." Id., at 20.

Summary of the Invention

The present invention provides in a preferred embodiment a system that achieves distribution of conventional cable services in traditional manners while
10 providing interactive television information services on a demand basis using a switching arrangement, and it does so while surprisingly permitting both types of service to be accessed, as in the past, by the single action of channel selection.

15 In a preferred embodiment the invention provides an interactive television information system, for providing interactive cable television service when coupled to a cable television system having (i) an information source available at a headend for supplying a plurality of information
20 services and (ii) an information service distribution network for delivering the information services to subscriber televisions. In this embodiment, the interactive television system has a plurality of home interface controllers. One such home interface controller is
25 associated with each subscriber television and provides an output in communication with the subscriber television and has (i) a signal input for television information signals and an input selection arrangement for selecting a given one of the television information signals at the signal input,
30 (ii) a channel selection arrangement for permitting a user to select an apparent channel, and (iii) a data transceiver operative over a data communications link. The embodiment also has a node, in television communication with the information source over a first path of the network and with
35 a group of the home interface controllers means over a second path of the network, and in data communications with the home interface controllers over the data communications

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link. The node selects and provides information services
obtained from the information source to each home interface
controller in the group based on data obtained over the data
communications link from each such home interface
5 controller.

In one embodiment, the node and each home interface
controller are so arranged that when any of a first group of
apparent channels is selected on a given one of the home
interface controllers, the node provides to it different
10 information services on different apparent channels in the
group all via the same television information signal
selected by the input selection arrangement of such given
home interface controller at a single carrier frequency for
such given home interface controller. In this way different
15 information services may be selected by the user simply by
changing the apparent channel. Furthermore, the channel
selection arrangement in each home interface controller
includes an arrangement for causing each selected channel in
a second group of apparent channels to correspond to a
20 different selected carrier frequency of a television
information signal at the signal input. In this manner,
selecting different apparent channels can also be used to
cause the selection of different conventional cable
channels. Thus channel selection permits the user to select
25 any information service, regardless whether it is
conventional or interactive.

In a further embodiment, the node includes an activity
detection arrangement for determining whether a given home
interface controller is to be placed in an interactive mode.
30 The node also includes a signal assignment arrangement for
causing, on an affirmative determination by the activity
detection arrangement, the input section arrangement of the
given home interface controller to select a given television
information signal present at the signal input. In this
35 embodiment, signal assignment is accomplished on a demand
basis for those home interface controllers determined to be
placed in an interactive mode. When the demand exceeds the

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supply, the assignment is achieved with rules for resolving the contention, for example, by permitting the first home interface controller to keep its assigned frequency until the activity detection arrangement detects that the
5 interactive mode is no longer in effect.

In related embodiments, the distribution network may include a plurality of express trunks. Each trunk has a first bandwidth portion carrying non-interactive television information services that are substantially identical in
10 nature and in bandwidth allocation among all trunks. A second bandwidth portion of each trunk carries television information services on a demand basis established by subscriber usage of the home interface controllers utilizing the trunk for service. The data communications link may
15 include a return path, from each home interface controller in a collection of neighboring home interface controllers, to the node in which a common trunk line is utilized for all of the home interface controllers in the collection.

This embodiment may further utilize a main trunk
20 carrying television information signals for non-interactive information services from the headend to each of the express trunks. Also an interactive trunk may carry television information signals for information services on a demand basis from the headend to each of the express trunks. A
25 splitter splits from the interactive trunk the television signals for information services on a demand basis for each of the express trunks. A group of couplers couples the signals from the main trunk and the splitter to feed each of the express trunks.

30 Brief Description of the Drawings

These and other aspects of the invention will be more readily understood by reference to the following detailed description taken with the accompanying drawings, in which:

Fig. 1 is a schematic of an interactive television
35 information system in accordance with a preferred embodiment of the present invention, showing relations with national and regional processing centers;

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Fig. 2 is a schematic showing the manner in which a multiheadend system with fiber optic interconnection may be employed to provide interactive television service in accordance with an embodiment of the invention;

5 Fig. 3 is a schematic showing an embodiment similar to that shown in Fig. 2, but in which a headend may have wireless communication with subscribers;

Fig. 4 is a schematic showing a mixed fiber optic coaxial cable system in accordance with a preferred
10 embodiment of the present invention;

Fig. 5 illustrates the general architecture of outbound signal flow and two-way control in a system in accordance with a preferred embodiment of the present invention;

Fig. 6 illustrates the manner in which the architecture
15 of a system similar to that of Fig. 5 uses controls to handle a wide range of information services in both analog and digital formats and distribution arrangements;

Fig. 7 provides further detail of the system of Fig. 6;

Fig. 8 shows the signal processing aspects of the
20 system of Fig. 7;

Fig. 9 shows detail of the splitter and combiner of Fig. 7;

Fig. 10 shows the allocation of frequency bands in the express trunks of Fig. 9;

25 Figs. 11A-11D show the structure of a chassis in accordance with a preferred embodiment of the present invention for holding multimedia controllers (MMCs) and modulator cards constituting components of the system illustrated in Fig. 7;

30 Fig. 12 illustrates the structure of analog MMC and modulator cards for the chassis of Fig. 11;

Fig. 13 illustrates the structure of preferred embodiments of the audio subsystems for the MMCs of Figs. 12 and 14;

35 Fig. 14 illustrates the structure of digital MMC and modulator cards for the chassis of Fig. 11;

Fig. 15 illustrates the structure of the data

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communications link at the headend (node) of the system of Fig. 7;

Fig. 16 illustrates the structure of the encoder/modulator of Fig. 12;

5 Fig. 17 illustrates the structure of the video processor of Fig. 16;

Fig. 18 illustrates the structure of the sync generator lock and scrambler timing section of Fig. 16;

10 Fig. 19 illustrates the structure of the audio processor section of Fig. 16;

Fig. 20 illustrates the structure of the rf upconverter section of Fig. 16;

Fig. 21 illustrates the structure of a scrambler for use with the modulator of Fig. 16;

15 Fig. 22 illustrates the seed data timing used in connection with the scrambler of Fig. 21;

Fig. 23 illustrates the structure of a descrambler suitable for use in a home interface controller in accordance with a preferred embodiment of the present invention for descramling a video signal that has been
20 scrambled by a system in accordance with Fig. 21;

Fig. 24 illustrates an alternative scrambling system;

Fig. 25 illustrates a descrambling system for use with video that has been scrambled by the system in accordance
25 with Fig. 24;

Fig. 26 illustrates the input and output structure of a home interface controller in accordance with a preferred embodiment of the present invention;

Fig. 27 illustrates an embodiment of the controller of
30 Fig. 26;

Figs. 28 and 29 illustrate embodiments of digital decompression and multimedia versions of the controller of Fig. 26;

Fig. 30 illustrates an alternative embodiment to the
35 system of Fig. 7 in which the node is disposed at a feeder;

Fig. 31 shows the bandwidth usage in a system in accordance with that of Fig. 30;

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Fig. 32 shows the general architecture of outbound signal flow and two-way control in a system in accordance with the embodiment of Fig. 30;

5 Figs. 33 and 34 illustrate use of the channel menu system in accordance with a preferred embodiment of the invention; and

Figs. 35-41 illustrate use of the carousel menu system and of the manner in which the invention in a preferred embodiment provides interaction with the user.

10

Detailed Description of Specific Embodiments

For the purposes of the description herein and the claims that follow it, unless the context otherwise requires, the terms "cable television environment" and
15 "cable television system" include all integrated systems for delivery of any information service to subscribers for use in connection with their televisions. These include conventional cable television systems utilizing coaxial cable for distribution primarily of broadcast and paid
20 television programming, cable television systems using fiber optics and mixed fiber optic-coaxial cable, as well as other means for distribution of information services to subscribers. Similarly, unless the context otherwise requires, the term "information service" includes any
25 service capable of being furnished to a television viewer having an interface permitting (but not necessarily requiring) interaction with a facility of the cable provider, including but not limited to an interactive information service, video on demand, local origination
30 service, community event service, regular broadcast service, etc. "Television communication" means providing an information service via a television information signal. A "television information signal" is any signal that may be utilized by a television for video display, regardless of
35 the form, including a standard NTSC-modulated rf carrier, an MPEG-compressed digital data stream, or any other format. "Interactive television service" means an information

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service that utilizes an interface affording two-way communication with a facility of the cable provider. When a node is said to be in an "interactive mode," it means that the node is providing an information service to the home interface controller; the home interface controller may, but need not, be furnishing data to the node as to what information service to provide.

In Fig. 1 there is shown the relationship of a cable television system in accordance with the present invention to regional and national processing systems. A headend 11 is in communication with a plurality of nodes 12 that in turn communicate with set top units 13, which below are referred to as "home interface controllers". Each of these home interface controllers has a remote control 14 operable by the user. Each headend 11 may obtain items for use in providing an information service from a regional processing center 15, which in turn may obtain some information services from a national processing center 16. The information services may include a wide range of offerings, such as classified advertising services, newspapers, advertising, televised catalogue ordering, video on demand or near video on demand, etc. Information services that are conventional television network programming may also be distributed from the national and regional processing centers.

Fig. 2 is a schematic showing the manner in which a multiheadend system with fiber optic interconnection may be employed to provide interactive television service in accordance with an embodiment of the invention. A pair of fiber optic cables 21 and 22 provide information services in clockwise and counter-clockwise directions (for redundancy in the event of disruption of the cables) from super headend 28 to headend clients 24 serving a number of cities 23. The super headend in turn may obtain conventional broadcast services as well as interactive information services from satellite receiver 27, and other information services from servers 25 from regional processing centers, as well as WAN

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and interexchange (IXC) facilities 26. Each headend client 24 may contain an interactive service node, here designated by the trademark ISX, a trademark of ICTV, the assignee herein.

5 Fig. 3 is a schematic showing an embodiment similar to that shown in Fig. 2, but in which a headend 24 may have two-way wireless communication using transceiver facilities 31 with subscribers. A transceiver facility 31 may include a high gain antenna system 31a communicating with a
10 transceiver 36 coupled to a television 37 at each subscriber location. The antenna system 31a radiates rf signals fed by transmitter 31b; the antenna 31a also receives signals from the subscriber transceivers and feeds them to receiver 31c. The transmitter 31b and the receiver 31c are linked
15 to fiber optic receiver 32 and fiber optic transmitter 33 respectively, which in turn communicate with the headend 24 over optical fibers 34 and 35.

Fig. 4 is a schematic showing a mixed fiber optic coaxial cable system in accordance with a preferred
20 embodiment of the present invention. In this embodiment, main fiber trunks 42a carrying conventional cable and broadcast programming go to optical receiver 43a, from which coaxial trunks 44A (express trunk A), 44B (express trunk B), and 44C (express trunk C) derive regular cable television
25 programming signals. Each express trunk has a first bandwidth portion carrying these non-interactive television information services that are substantially identical in nature and in bandwidth allocation among all express trunks.

An interactive fiber trunk 42b in Fig. 4 carries
30 desired interactive information services in the outbound direction that are not provided over main fiber trunks 42a, and these information services are fed into optical receiver 43b. As will be shown in further detail in Fig. 9, the electrical output of the optical receiver 43b includes
35 information services in separate spectral portions for each of express trunks A, B, and C. This output is provided to hub splitter 46. The information services for each of

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express trunks A, B, and C are then translated into common spectral portions by hub splitter 46, and then fed to the designated trunks, where they are coupled to the conventional signals via couplers at locations 45a, 45b, and 5 45c on trunks 44a, 44b, and 44c respectively. It should be pointed out that although the information services for each of these trunks occupy similar spectral regions, their information content is different, since the information content of the information services on trunk A is supplied 10 on demand to the home interface controllers served by trunk A, the content on trunk B is supplied on demand to the home interface controllers served by trunk B, and the content on trunk C is supplied on demand to the home interface controllers served by trunk C. Thus a second bandwidth 15 portion of each express trunk carries television information services on a demand basis established by subscriber usage of the home interface controllers utilizing the trunk for service.

The path of inbound data from the each express trunk 20 44A, 44B, and 44C is from a splitter at each of locations 45a, 45b, and 45c respectively to hub combiner 47. The inbound data, like the outbound interactive television information services, on each of the express trunks occupy similar spectral regions, although the data on each express 25 trunk have different information content reflecting the particular demands made by the home interface controllers using each particular express trunk. The inbound data from each trunk are frequency shifted by hub combiner 47 in the manner described in further detail in connection with Fig. 9 30 to cause the data from these trunks to occupy separate spectral regions, and the output of the combiner 47 feeds optical transmitter 42c. The optical transmitter 43c feeds the optical fiber trunk 42c to provide a common trunk return path, for all the home interface controllers served by 35 express trunks 44A, 44B, and 44C, for the interactive headend 41.

Fig. 5 illustrates the general architecture of outbound

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signal flow in a system in accordance with a preferred embodiment of the present invention. At the super headend, for example, item 28 in Fig. 2, a variety of sources of information services are available from satellites, antennas, servers, and gateways, and they are routed to subscribers via routing switchers 52. A portion of these information services may, but need not, be provided to all subscribers as basic non-interactive service. The routing switchers 52 feed appropriate modular multimedia controllers 53 (MMCs) which may provide appropriate processing for providing the service in question to each subscriber. Differently configured cards are used depending on the nature of the information service. Where the information service is interactive, an individual MMC 53 is assigned on a demand basis to each requesting home interface controller, which is in data communication with MMC, and the MMC provides interactive television information service. Post switchers 54 switch the MMC outputs to appropriate modulators 55, which are in turn grouped so that their outputs feed rf combiners used for each fiber optic transmitter 57 and associated optical fiber 58. As indicated by item 59, two-way control, to be discussed in further detail below, is exerted over the outbound signal flow from end to end.

Fig. 6 illustrates the manner in which the architecture of a system similar to that of Fig. 5 may handle a wide range of information services in both analog and digital formats and distribution arrangements. A super headend 28 may obtain some information services via television receive only (TVRO) system 61a and downlink 62a, as well as over line 61b using, for example, T1 or T3 bands or ATM digital protocols and gateways 62b. The super headend 28 furnishes information services 64 via switch 65 to the headend 11. These information services may include video on demand, near video on demand, and multimedia presentations. They are provided under the general control of control manager 62c over control bus 63a. A central database may be maintained

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on server 64a for all subscribers as to the types of service subscribed to and terms for delivery of service, and the delivery of services to the subscribers is monitored and controlled over the control bus 63a by service manager 63.

5 The control manager also has supervisory control on bus 63a over the input switch 66 to headend 11. This switch 66, having an input from the output switch 65 of the super headend 28, feeds the analog MMCs 67a for analog signals in conventional formats and digital MMCs 67b for signals in

10 digital formats. The MMC outputs are then subjected to modulators for appropriate frequency translation (item 68a) and to distribution 68b over the cable network to subscribers having analog converters 69a or digital converters 69b. Interactive information service is enabled

15 by the net manager 66a, which maintains two-way data communication over gateway 66b with each of the converter types 69a and 69b.

Fig. 7 provides further detail of a system in accordance with Figs. 4-6. The information sources 51 from

20 the super headend 28 feed its switch 65, the output of which is directed to the headend 11, which contains, in a node 77, input switch 66 feeding a series of MMCs, usage of which is allocated on a demand basis. As described in connection with Fig. 4, conventional cable broadcast channels are

25 routed over main fiber trunk 42a to express trunks 44A, 44B, and 44C. An interactive fiber trunk 42b carries interactive channels (here called "virtual channels" for reasons that will be described below) to splitter 46 for coupling at 45a, 45b, and 45c to express trunks 44A, 44B, and 44C. Combiner

30 47 takes inbound data from each of the express trunks for delivery over common data fiber trunk 42c to the node at the headend. Analog television information signals from appropriate analog MMCs are processed by scrambling at 73a and modulators at 73b, whereas digital television

35 information signals from appropriate digital MMCs are processed by combining them into a composite QAM (quadrature amplitude modulation) signal before going to modulators at

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73b. In this embodiment (as contrasted with the otherwise similar embodiment of Fig. 5), the modulators are preferably capable of modulating a carrier that is tunable by the network manager 66a, so that any given modulator may be
5 configured to best handle demands placed on the system. (In Fig. 5, the modulators are associated with carriers at dedicated frequencies, and the inputs to the modulators are varied by switch 54.) Depending on capacity of the cable system and the information services sought to be delivered,
10 some of the cable broadcast channels 72 may alternatively be provided, over path 72a to the MMCs, as information services on demand furnished by node 77. (Such an approach may conserve bandwidth on the cable distribution plant 68b or permit more offerings to be made to subscribers.)
15 Additionally, the path 72a permits the MMCs operating interactively to permit a subscriber to make overlays on otherwise conventional cable television programming. The outputs of items 73b are then combined by combiner 73 and fed to the interactive trunk 42b. The cable distribution
20 plant 68b includes bridger amplifiers 74, feeders 74a, feeder amplifiers 74b, and cable drops such as 75a, 75b, and 75c serving homes 76a, 76b, and 76c.

The information services can be provided to a subscriber over virtual channels in which the channel number
25 changes for different interactive information services, even though the various information services may be provided over a fixed frequency input to the set top, with the control data from subscriber's set top causing the headend to supply a different information service as the subscriber appears to
30 be changing the channel. This feature is described in further detail below.

The modular structure of the node 77 and the arrangement of the distribution plant 68b permit serving simultaneously homes such as 76a with a conventional
35 converter, 76b with a digital set top having MPEG decompression, and 76c with a digital set top having multimedia capability achieved with a home-based central

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processing unit. Each home has a home interface controller operating as part of the set top configured as described below.

Fig. 8 shows the signal processing aspects of the system of Fig. 7. This figure does not show the distribution system, and therefore applies equally to telephone or cable distribution architectures. An analog MMC 82a in the node at headend 11 will typically pick off, under control of a central processing unit (CPU), a television information signal in digital form from switch 66 and then decompress the signal, subject it to appropriate frequency translation by a modulator and provide over the distribution system to homes where a conventional set top in block 81a can permit the signal to be demodulated for display by the television. A digital MMC 82b in the node at headend 11 also operates under control of a CPU, but does not need to decompress the signal. The signal is subjected to appropriate frequency translation and then distributed to the home. At the home, in block 81b, the signal is demodulated and decompressed at the set top for display by the television. In the case of digital multimedia set tops in the home, it is primarily frequency translation that needs to be provided at the headend node, which is achieved by gateway card 82c, and the set top in block 81c includes the CPU for processing of the signal from the headend.

Fig. 9 shows detail of the splitter 46 and combiner 47 of Figs. 4 and 7. Signals fed into splitter 46 include spectral regions for television information signals 91A for information services on demand for subscribers served by express trunk 44A and for outbound data 95A for providing interactive service to these subscribers. Similarly, there are spectral regions for television information signals 91B for information services on demand for subscribers served by express trunk 44B and for outbound data 95B for providing interactive service to these subscribers; also television information signals 91C for information services on demand for subscribers served by express trunk 44C and for outbound

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data 95C for providing interactive service to these subscribers. The signals in these spectral regions are subject to frequency translation so that corresponding bands 92A, 92B, and 92C in each of express trunks 44A, 44B, and 44C respectively carry television information signals for information services on demand to subscribers served by these trunks. Frequency translation is also used so that corresponding bands 94A, 94B, and 94C carry outbound (downstream) data for providing interactive service to these subscribers in each of express trunks 44A, 44B, and 44C respectively. As discussed above in connection with Fig. 4, conventional cable channels occupy corresponding bands (here shown as item 90) in each of the express trunks.

Inbound (upstream) data for interactive service are handled by the hub combiner in the reverse manner. The data initially occupy corresponding bands 93A, 93B, and 93C on trunks 44A, 44B, and 44C, and are subject to frequency translation by combiner 47 so that the inbound data from trunk 44A occupy a first spectral region 96A, the inbound data from trunk 44B occupy a second spectral region 96B, and the inbound data from trunk 44C occupy a third spectral region 96C.

Fig. 10 shows the allocation of frequency bands in the express trunks 44A, 44B, and 44C. The return data in band 93 occupy the 15-18 MHz region. The downstream data in band 94 occupy the region above channel 4 in the range 72-76 MHz. The television information signals for interactive service in band 92 are located above the allocation 90 for conventional cable broadcast channels. These frequency assignments are merely illustrative, however. Moreover, the television communications and the data communications between node and subscriber home can be achieved in a wide variety of formats. Instead of putting each television information signal on a separate carrier at a separate frequency in the express trunks 44A, 44B, and 44C, for example, the signal could be provided as a compressed digital data stream on a time-shared basis or as addressed

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packets. In fact, data communications in both directions (inbound to the node and outbound to the home interface controller) in accordance with a preferred embodiment of the invention utilizes slotted ALOHA protocols, so that data communications utilizes addressed packets.

Figs. 11A-11D show the structure of a chassis in accordance with a preferred embodiment of the present invention for holding multimedia controllers (MMCs) and modulator cards constituting components of the system illustrated in Fig. 7. A rack 112 in Fig. 11A holds switch 66 of Fig. 7 along with the MMCs and encoder and modulator cards 73a and 73b of Fig. 7. The MMCs and other cards are mounted in rows 114 of the rack 112. Each row of cards is supported on a chassis 113 shown in Fig. 11D. The MMCs (called processor line cards in Fig. 11B and processors in Fig. 11D) are plugged into the left, rearward portion of the chassis 113, and the encoder and modulator cards are plugged into the right, forward portion of the chassis. The central vertical member 115 of the chassis provides on both sides buses for digital and rf communication, as well as power for the cards that are mounted on either side of the chassis. The chassis 113 is mounted in the rack 112 so that the processor line cards 67 face the reader in Fig. 11A. It can be seen, from the code letters in Fig. 11A for the card types listed in Fig. 11B, that a wide range of specialized MMCs may be employed to permit the system to provide a wide range of information services in a wide range of formats. Thus MMCs may be employed for movies only (A) (providing, for example, decompression of stored digitally compressed movies in MPEG format), for providing multimedia presentations using software utilizing the Intel 486 microprocessor (B) or the Intel Pentium microprocessor (C), or using 3DO or SGI formats (D and E). Digital MMCs (item (configured with corresponding modulator as suggested in item 82b of Fig. 8) (item F), as well as various communications cards including some with Live Sync (permitting interactive overlays on broadcast programming)

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(G) and permitting Home-v-Home communications (by which subscribers in two or more homes may communicate interactively, for example, in a computer game) (H) and gateway cards (I) are also provided. (Live Sync and Home-v-
5 Home are trademarks of ICTV Inc., the assignee herein.)

Fig. 12 illustrates the structure of an analog MMC 125 and a scrambler-modulator card 126 for the chassis of Fig. 11. The MMC includes a video sub-system 121 and audio sub-system 122 operating under control of CPU 127 and control
10 line 128 from the net manager 66a of Fig. 7. Line 128 also is in communication with sources of information services, which receive decompression by block 121b and are mixed in the video effects and mixer module 121d. The module 121d
15 also receives input from graphics digital-to-analog converter 121c (providing, among other things, display for subscriber interaction) utilizing data from RAM/ROM storage 121a and control/content bitstream data obtained over line 128. TV tuner 129 also provides video signals from
20 conventional cable television channels over line 72a to the module 121d. The RGB/YUV output of the module 121d is provided to the scrambler-modulator card 126. The module 121d also receives a composite sync signal input from scrambler/encoder 123 for use in providing a system timing reference to the video overlay.

25 The audio sub-system 122 in Fig. 12 has a coupling to TV tuner 129 (redrawn in this sub-system for convenience in reference) to provide audio signals from conventional cable television channels over line 72a to a mixer 122e, which also receives signals from background music source 122b,
30 tactile response source 122c (for use in connection with the subscriber's remote control 14 in interactive television service), and digital program source 122d, which obtain control and content data over line 128. MTS stereo audio output of the mixer 122e is then provided to the modulator
35 124 of card 126.

The scrambler-modulator card 126 takes the RGB input from the video sub-system 121 and encryption control signal

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from CPU 127 to provide a scrambled video output to modulator 124. The audio output of the mixer 122e of the audio sub-system 122 is fed directly to the modulator 124. The frequency of the carrier that is modulated is determined
5 by control of the net manager over line 128.

The structure of digital MMC and modulator cards 141 and 142 shown in Fig. 14 is similar to that of the analog cards in Fig. 12. The TV tuner and graphics digital-to-analog converter outputs are mixed as in Fig. 12. Instead
10 of decompressing the digital video source before feeding it to the mixer module 121d, however, the compression here is maintained and sent directly to MPEG mixer 144a as MPEG source 2. The analog output of mixer 121d is compressed by compression encoder 144, which also receives the MTS audio
15 output. The output of the compression encoder serves as source 1 input to MPEG mixer 144a. This MPEG output is then sent to encoder 143 and modulator 124. The MPEG mixing in block 144a is achieved by recognizing that the graphics overlay data from digital-to-analog converter 121c provides
20 video content that does not change rapidly, and therefore can be implemented by causing the mixer to affect only the I-frame picture elements in the MPEG compression scheme with respect to the overlay content. (MPEG's compression scheme is described in "C-Cube CL450 Development Kit User's Guide,"
25 dated December 14, 1992, Chapter 2, available from C-Cube Microsystems, Milpitas, California, which is hereby incorporated herein by reference.) The MPEG mixer 144 includes an arrangement for providing the source 1 MPEG-encoded digital signal to a buffer; an arrangement
30 for extracting from the source 2 digital signal I-frame picture elements to be overlaid; and an arrangement for overlaying the I-frame picture elements from the source 2 digital signal onto the corresponding regions of the I-pictures of the source 1 digital signal. The other picture
35 types of the source 2 signal are not permitted by the mixer to modify portions of the I-picture that have resulted from the mixing.

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Figs. 13A-13C illustrate the structure of preferred embodiments of the audio subsystems for the MMCs of Figs. 12 and 14. In these embodiments, there are provided mixer 122e and, controlling its operation, a CPU 131, which may, but
5 need not, be the same as CPU 127 of Figs. 12 and 14. The CPU 131 of Fig. 13A is operated in association with synthesizer 133. The content bitstreams on line 128 may include digitally compressed audio that is decompressed by block 135. These embodiments also have an off-air tuner
10 132, which may, but need not, be the same as tuner 129 of Figs. 12 and 14. Other formats of digital audio, shown here converted by digital-to-analog converter 134, are also within the scope of the use of these embodiments. In lieu of synthesizer 133 there may be provided a second
15 decompression unit 135a (Fig. 13B), and similarly, in lieu of digital-to-analog converter 134, there may be provided a third decompression unit 135b.

Fig. 15 illustrates the structure of the data communications link at the headend (node) of the system of
20 Fig. 7 with subscriber home interface controllers downstream. Outbound data leave gateway 66b via line 153a where they go out over the interactive fiber trunk 42b. Inbound data enter gateway 66b via line 155a from common return line 42c. The outbound data leave from rf
25 modulators 153 utilizing frequency shift key (FSK) encoding via encoders 152, and the inbound data enter via rf demodulators 155 using FSK detectors. Communications processing of the data is handled by communications processor 151 under control of compatible PC having
30 microprocessor 156a, ROM 156b, and RAM 156c. The control may be managed additionally via network transceiver 157. The slotted ALOHA protocol used in a preferred embodiment for inbound and outbound data communications requires that each home interface controller is assigned an address for
35 data packets that are used in communication with the node. When a subscriber causes his home interface controller to select a virtual channel, the net manager 66a of the node is

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signalled to that effect. The net manager 66a, on determining that a given home interface controller is sought to be used for interactive television service (i.e., that the given home interface controller should be placed in an interactive mode), allocates additional data communication bandwidth for data communication with the particular home interface controller, so as to establish on a demand basis the data communications bandwidth utilized by the particular home interface controller.

- 10 Depending on the nature of the information service selected by the subscriber in selecting a particular virtual channel, an appropriate MMC is assigned by the net manager 66a on a demand basis to the serve the subscriber's home interface controller while it is in the interactive mode.
- 15 In the case of many types of interactive television service, the home interface controller will have exclusive use of the assigned MMC, a "private line" to it over the data communications link and the interactive trunk 42b. In the case of near video on demand, however, several home
- 20 interface controllers may share the same time slot on a movie, for example, and these subscribers would have a "party line" to the MMC.

As described in further detail below, appropriate MMCs can be used to provide overlays or other graphics on the television screen when the home interface controller is appropriately equipped.

Fig. 16 illustrates the structure of the encoder/modulator 126 of Fig. 12. It includes a video processor 164 that has an RGB/YUV input and produces a scrambled NTSC video output on line 123d. The video processor has inputs from sync genlock/scrambler timing block 163, including 3.58 MHz color subcarrier on line 163d, burst flag on line 163c, invert control on line 163b, and sandcastle pulses on line 163a. The sync genlock/scrambler timing block 163 has inputs including genlock/free run select and encryption control 123c from CPU 127, and provides composite sync output on line 123a. The sync

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genlock/scrambler timing block 163 also provides MTS subcarrier reference signal over line 123e to audio processor 162. The audio processor 162 includes standard MTS stereo audio inputs for left, right, and secondary audio program. The scrambled NTSC video signal on line 123d together with the MTS composite audio output of audio processor 162 are used to modulate a carrier at a desired frequency (established by the net manager 66a of Figs. 6 and 7) by rf upconverter 161.

10 Fig. 18 illustrates the structure of the sync genlock/scrambler timing block 163 of Fig. 16. It is used to generate a series timing signals for both scrambling and overlay synchronization that are either genlocked to an external CATV signal or are otherwise inherently stable.

15 The TV tuner 129 of Fig. 12 additionally includes demodulator 186 in Fig. 18 and sync separator 185. The sync separator includes stripped horizontal sync output from conventional cable television video on line 181a and frame reset signal on line 182c. The stripped horizontal sync

20 signal on line 181a forms a reference for phase-locking a 3.58 MHz oscillator in color subcarrier lock block 181, the output of which is furnished on line 163d. The signal on line 163d is divided down to provide a horizontal reference signal on line 182d. The signal on line 182d provides a

25 reference for phase locking the generation of sync signals by sync genlock block 182. This block provides composite sync and blanking signals on lines 182a and 182b, as well as frame sync, horizontal sync, burst flag, and MTS subcarrier reference on lines 184a, 184b, 163c, and 123e respectively.

30 Block 182 provides frame sync and horizontal sync signals to crypto logic block 184. It also provides composite sync and composite blanking signals to mode logic block 183. The crypto logic block 184 and mode logic block 183 work in cooperation with one another to produce sandcastle pulses on

35 line 163a in the manner described below in connection with Fig. 21. The sandcastle pulses are used to provide scrambled NTSC video in the manner also described below in

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connection with Fig. 21.

Fig. 21 illustrates an implementation of scrambling by crypto logic block 184 of Fig. 18 in cooperation with mode logic 183 and video processor 164. The scrambling is achieved by removing substantially all sync pulses from the NTSC signal. Infrequent (at least once per frame, two fields per frame) and randomly spaced horizontal pulses (sandcastles) are then reinserted. The effect of such scrambling is to deprive the standard NTSC receiver from obtaining horizontal and vertical sync lock with the incoming signal. This causes rapid horizontal and vertical roll of the picture. During the intervals in which the removed sync signals were formerly present, the scrambler clamps the video to a nearly white level. As a result when the video signal tends toward levels corresponding to black, the receiver frequently interprets this video content as a sync signal, with the further effect that the horizontal rolling and the vertical rolling are aperiodic.

The sandcastles are reinserted at a pseudorandom position in each consecutive frame, determined by vertical random number generator 212 in Fig. 21. The line counter 214 is clocked by horizontal sync presented on line 184b, and is reset by frame sync pulses on line 184 each frame. The line counter 214 stores a new number from the vertical random number generator 212 each time a frame reset pulse is received. When line counter 214 has counted down to zero from the stored number, it triggers timing pulse generator 216 to send a pulse into mode logic control 183. Occasionally, on command from the load/count line 212a, the timing pulse generator 216 is caused to produce sandcastles in a plurality of successive lines. A command from the load/count line 212a also triggers the loading from buffer register 211 of a previously stored seed value (loaded from line 211a) into both the vertical random number generator 212 and the horizontal random number generator 215. The seed value and load/count numbers over lines 211a and 212a are provided by CPU 127 of Fig. 12 on command of the net

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manager initially each time an MMC is assigned to serve a particular home interface controller and subsequently whenever the home interface controller reports over the data communications link that it has lost sync. Additionally the
5 CPU 127 may be programmed to generate new seed values and load/count numbers in accordance with any desired strategy to resist efforts at rederiving sync without authorization.

Each sandcastle pulse looks like the sum of the composite blanking and composite sync signals. The shape of
10 the sandcastle pulse is therefore such that when summed in the summer 172 of Fig. 17 with sync suppressed video, the result is a signal that has a normal NTSC blanking period once per frame, and moreover, the normal blanking period occurs at pseudorandomly located lines in successive frames.
15 The sandcastle pulses appear on line 163a from mode logic controller 183. Composite sync signals 182a and composite blanking signals 182b are therefore summed and gated by the mode logic control 183 on receipt of pulses from the timing pulse generator 216 as described above. The width of the
20 timing pulse generator signal over line 184c, which governs the duration of the sandcastle pulse, is equal to the horizontal blanking period.

In a manner analogous to the functioning of the vertical random number generator, the horizontal random
25 number generator 215 issues a pulse at pseudorandom line intervals. Each pulse has the duration of the active video portion of one horizontal line, and is fed over input 163b so as to cause the video processor 164 to produce entire horizontal lines having inverted video.

30 Fig. 17 illustrates the structure of the video processor 164 of Figs. 16 and 21. Block 171 shows a RGB/YUV to NTSC converter that is supplied with conventional inputs (including RGB/YUV, 3.58 MHz color subcarrier, and burst flag) but, in this case, lacking any sync or blanking input
35 signals. The converted output is standard NTSC with the exception that all sync information is suppressed. The inverter 173, under control of pulses present over line

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163b, operates to invert the video on a random line-by-line basis in the manner described in connection with Fig. 21 above. The inverter output is then summed in summer 172 with the sandcastle pulses to produce the scrambled NTSC waveform described above.

Fig. 23 illustrates the structure of a descrambler suitable for use in a home interface controller in accordance with a preferred embodiment of the present invention for descrambling a video signal that has been scrambled by a system in accordance with Fig. 21. It will be recalled in connection with Fig. 21 that the seed value and load/count numbers over lines 211a and 212a are provided by CPU 127 of Fig. 12 on command of the net manager initially each time an MMC is assigned to serve a particular home interface controller. The same seed value is also provided to the particular home interface controller and is stored in the buffer register 231. Each time a new seed value is loaded into buffer register 211 of the scrambler, the same seed value is loaded into the buffer register 231 of the descrambler. The value in register 231 remains in the register until clocked into the vertical and horizontal pseudorandom number generators 232 and 235 respectively by a pulse from the timing pulse detector 238. The relative timing of the seed data, and the load/count pulses, and the occurrence of sandcastles in the scrambled NTSC video are shown as items 221, 222, and 223 of Fig. 22.

Timing pulse detector 238 monitors the incoming scrambled video over line 238a. The timing pulse detector 238 produces a clocking pulse when it detects the plurality of pulses produced in the scrambled NTSC video when the scrambler in Fig. 21 received a load/count pulse over line 212a. (In this manner the timing pulse detector causes the generation a pulse at a time with respect to the received scrambled signal corresponding generally to the occurrence of the load/count pulse when the original signal was being scrambled.) The timing pulse detector clocking pulse then causes the stored seed value to be loaded into the

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pseudorandom number generators 232 and 235.

The timing pulse generator 238 also detects the occurrence of single sandcastle pulses, and these are used to trigger the loading of the line counter 234 and the reset of the sync generator 237. This generator is phase-locked to the color burst and therefore produces the necessary sync signals to reconstruct a descrambled NTSC signal. The composite sync and composite blank signals from the generator 237 feed sandcastle summer 2331 to produce a full series of sandcastles for every line and the entire NTSC frame structure. The output of summer 2331 goes to sandcastle complement generator 233, which gates the input every time a sandcastle occurs on the scrambled video input line 238a. The output of the sandcastle complement generator is therefore a stream of sandcastles that lacks a sandcastle at each time, and only at each time, a sandcastle is present in the scrambled video signal. This output is fed to the decoder/amplifier 236, where it is summed with the scrambled video signal to produce an output that has a sandcastle at every line and is therefore a descrambled NTSC video signal.

In a manner analogous to the function of the inverter control on line 163b of Figs. 21 and 17, there is produced an inverter control signal on line 235a by the horizontal pseudorandom number generator 235, which produces a pulse at time corresponding to the production of a pulse by horizontal pseudorandom number generator 215. This control signal on line 235a causes a second inversion (and therefore restoration) of the previously inverted line of video caused by inverter 173 of Fig. 17. The result is fully restored NTSC video on line 236a.

Fig. 19 illustrates the structure of the audio processor section 162 of Fig. 16. Left and right audio inputs from audio sub-system 122 are provided to the sum and difference matrix 191. The L + R sum output on line 191a is subjected to low-pass filter 1921 and pre-emphasis filter 1923. Similarly, the L - R difference on line 191b

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is subjected to low-pass filter 1922 and dbx compressor 1924 and the compressor output is fed to a double balance mixer 193. MTS subcarrier reference signal on line 123e is subject to frequency division by divider 195, and further
5 frequency division by halver 196. The output of the first divider 195 is bandpass filtered by item 1971, and the resulting output is furnished to the double balanced mixer, so as to produce a double sideband suppressed carrier signal on line 193a. This signal is summed by summer 194 with the
10 pre-emphasized L + R signal on line 1923a and the SAP subcarrier signal, the latter which is provided by SAP subcarrier generator 198, to which the SAP signal from audio sub-system 122 is supplied. This produces a composite BTSC signal on line 162a, which is furnished to rf upconverter
15 161 described in Fig. 16.

Fig. 20 illustrates the structure of the rf upconverter section 161 of Fig. 16. The inputs include BTSC audio on line 162a and scrambled NTSC video on line 123d. The video input is provided to an a.m. modulator 2011 and the audio
20 input is provided to an f.m. modulator 2012, and the respective modulator outputs are summed in summer 202. The output of the summer is bandpassed by filter 2031 and amplified by amplifier 2032. The amplifier output is mixed with the signal from first local oscillator 2043, and the
25 desired upper sideband is amplified and bandpass filtered by amplifier 2042 and filter 205. This intermediate frequency signal is then run through amplifier 2051 and mixed in mixer 2052 with a signal from a second local oscillator 2053 that is frequency agile (here a phase-locked oscillator). The
30 output is amplified (in amplifier 2053) and low-pass filtered by filter 2054, to eliminate the upper sideband, and the resulting signal is amplified by amplifier 2055 and provided as an output on line 161a. (This output is fed to combiner 73 of Fig. 7.)

35 Fig. 24 illustrates an alternative scrambling system. The system has an NTSC sync stripper 241 that supplies sync stripped video to a mixer 243, which masks sync signals by

supplying a chroma subcarrier at all times, including during horizontal and vertical retrace. In addition, the luminance signal is caused to be present at all times.

These results are achieved by using the vertical and horizontal sync outputs from stripper 241 to provide an output from OR gate 2461 when either of both of vertical and horizontal retrace signals are present. This output gates via switch 242 a pink noise luminance masking signal from generator 2421 into the mixer 53. This output also is affected via switch 247 by a pink noise signal from generator 2471 used in turn to modulate phase-locked loop oscillator 244 to produce a modulated chroma subcarrier masking signal. This signal is subject to an optional programmable phase delay 245 to cause different phase shift of the signal during the color burst interval on a line-by-line basis in accordance with a phase offset generated by pseudo random generator 2451. The composite sync signal output from stripper 241 is provided with an encrypted value for the current phase shift caused by generator 2451. The encrypted value is obtained from DES encoder 248, and this encrypted value, a digital signal, is placed on the signal during the vertical blanking interval as a binary pattern by vertical blanking interval data encoder 249. The composite sync signal is then subjected to an optional variable time delay by delay 2491 by a reference value that is also obtained from pseudo random generator 2451. Of course a separate generator could be used, provided that the value obtained from such a generator is also encoded on the composite sync signal. This resultant scrambled composite sync signal is then provided as an output. This system therefore provides a continuously present chroma subcarrier, a continuously present luminance signal, and shifts the color burst by a random amount. The scrambled video is therefore relatively difficult to descramble, without access to the method of scrambling.

Fig. 25 shows a video descrambler system for descrambling the video scrambled in accordance with a system

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such as shown in Fig. 24. The scrambled video signal provided over line 259 is gated off during both the vertical and the horizontal retrace intervals by gate 251, thereby removing the masking signals that interfere with proper

5 sync, and the proper sync signal, presented on line 2543, is also added to mixer 253 to provide the composite video output over line 2532. The scrambled sync present at input 258 is first used to provide the encrypted delay information (if an encrypted delay is used) which is decoded from the

10 vertical blanking interval data by decoder 255 and deciphered by DES decoder 256. The scrambled sync signal is run through the programmable time delay 257 to provide a composite sync signal that is in phase with the video. Sync separator 254 provides separate outputs for vertical and

15 horizontal sync as well as a gate signal for the color burst. The vertical and horizontal sync signals are run through NOR gate 2541 and OR gate 2542, so that 251 gates off the video during vertical and horizontal retrace except during color burst. Optional video decoder 252 separates

20 the chroma subcarrier (in the event that it is phase shifted), and the separated subcarrier is run through optional programmable phase delays 2531 in an amount specified by the decrypted delay data to recover the original phase of the subcarrier. The resultant corrected

25 subcarrier is mixed with the luminance and audio subcarrier and the composite sync signal by mixer 253 to provide a descrambled composite video signal over line 2532.

Fig. 26 illustrates the input and output structure of a home interface controller 13 in accordance with a preferred

30 embodiment of the present invention. The controller includes input and output connections 261 for cable television rf, a video cassette recorder interface 262, an expansion interface 263 (for providing for baseband video; ports for printer, modem, and computer; and power line

35 interface), infra-red transmitter port 264 for communication with conventional set top, video cassette recorder, and television, infra-red receiver port for communication with

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remote control 14, rf output 266 for communication with a television receiver, and baseband outputs 267 for communication with a television monitor.

Fig. 27 illustrates an embodiment of the controller of Fig. 26 suitable for analog television signal inputs. The rf cable television input 2711 feeds diplex filter 271, the high pass section of which feeds television information signals and downstream data to line 2712 and splitter 2714 for division among VCR rf output at 2782, control data receiver 2751 and tuner 272. The low pass section receives upstream data communications from control data transmitter 2752 over line 2713. Tuner 272 is switched between VCR rf output 2782 and the television information signals from line 2712. The tuner's output is fed to descrambler 373, which is bypassed by switch 2731. Genlock block 2732 provides sync signals necessary for permitting overlay controller 2733 to function properly with the tuner output. The overlay controller's output is fed directly to baseband video output 267a, and the tuner's audio output is routed through volume control 2741 to baseband audio output 267b. A channel 3/channel 4 modulator 274 coupled to these baseband outputs provides rf output over line 266 to the subscriber television. Switch 2741 switches the television between the home interface controller's television information signals and the VCR's rf output. Data communications involving the data receiver 2751 and the transmitter 2752 is handled by data communications processor 275, and the information flow is via data bus 279 to and from set top processor 276, infra red interface 2761 for the remote control 14, overlay controller 2733, tuner 272, and volume control (setting) 2741.

Figs. 28 and 29 illustrate embodiments of digital decompression and multimedia versions of the controller of Fig. 26. The embodiment of Fig. 28 is similar to that of Fig. 27, except that there is also provided a high-speed data receiver 281 having an input connected to splitter 2714. The output of the high-speed receiver feeds digital

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decompression module 282. This module has an audio output feeding mixer 283 along with the audio from tuner 272 and a video output that can be switched into the overlay controller 2733 by switch 285, the other position of which causes the overlay controller 2733 to obtain its video solely from the analog origin as before.

The multimedia embodiment of Fig. 29 represents a further enhancement of the embodiment of Fig. 28. In addition to the high-speed data receiver 281, there is a high-speed data transmitter 291. These communicate with data bus 279 via high-speed data interface 292. Frequency control of communication at these data rates is assisted by frequency control block 2941. Audio mixer 295 operates under control of sound microprocessor 2943. Additional effects are achieved by multimedia processor 2944, and overlay and effects block 2942.

Fig. 30 illustrates an alternative embodiment to the system of Fig. 7 in which the node 302 is disposed at a feeder 74a, typically proximate to a bridger amplifier 74. In some embodiments where a bridger amplifier may serve a plurality of feeders, the node may similarly serve home information controllers on each of these feeders. In this embodiment main trunk 301 feeds express trunks 44. Bridger amplifiers 74 are disposed at locations where the feeders 74a are connected to the trunks 44. At a tap 303 is disposed drop 75 to a subscriber home having a home interface controller 13 and remote control 14.

Fig. 31 shows the bandwidth usage in a system in accordance with that of Fig. 30. The bandwidth is limited at the node 302 by a low pass filter so that digital carrier signals 319 at the bandwidth portion above the region 315 allocated to ordinary cable channels cannot reach the home interface controllers downstream of the node on the feeder 74a. (Alternatively, the bandwidth may be limited naturally by the bridger amplifier 74, with the node in communication with the trunk 44.) The removed digital signals in the bandwidth 319 may typically carry compressed digital